

Recent Physical Oceanography Data Update and Observation and Model Plans

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Overview



1. Introduction
2. Bottom Stress and circulation are central to the site designation process.
 - a) Consideration of all possible sites is only possible if models are used to “interpolate” between the limited location and times data is available.
 - b) A well tested model requires data for evaluation.
3. Summary of the data required to predict the range of circulation and bottom stresses expected throughout the ZSF.
4. Summary of data available
5. Observation Plan
6. Modeling plans

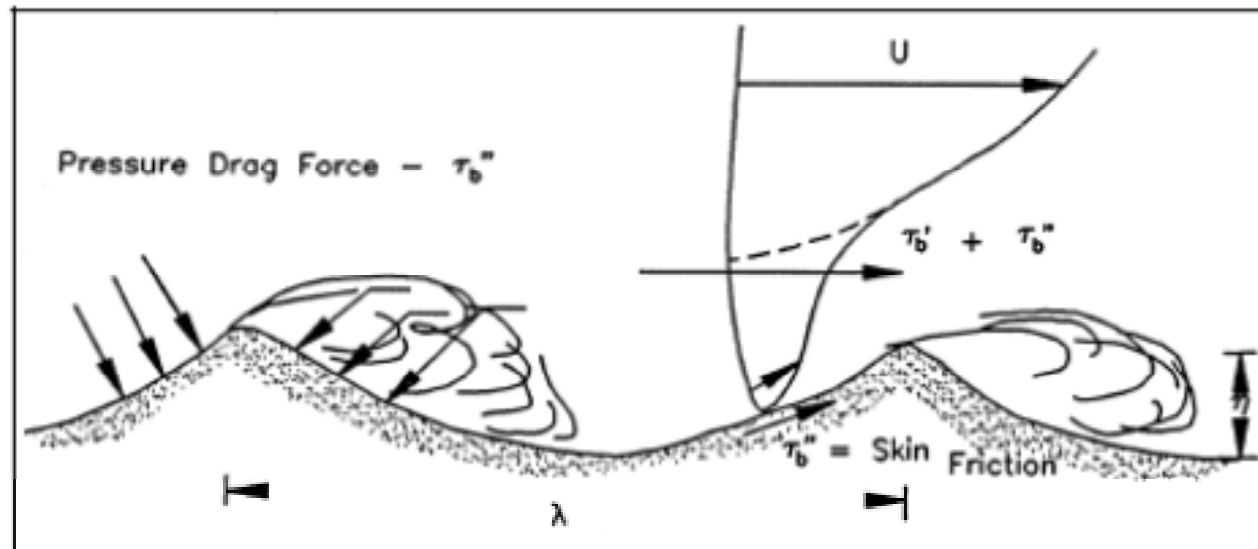
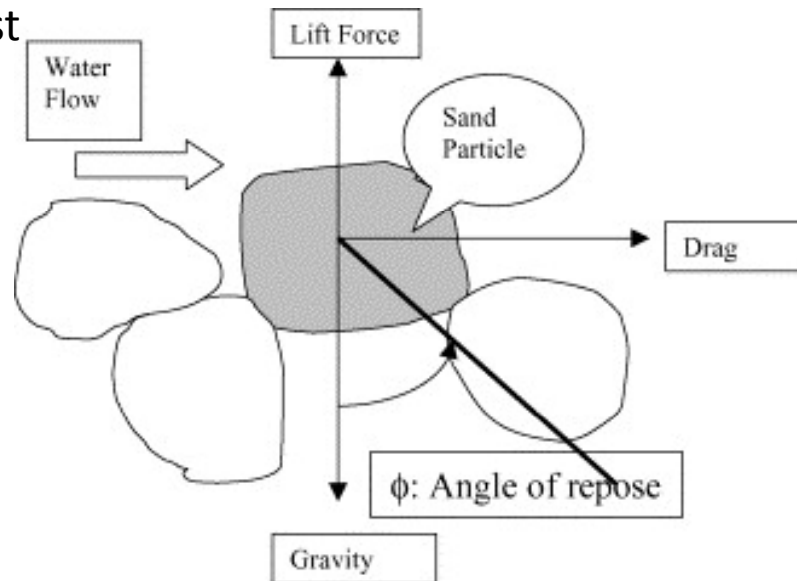
Physics of Sediment Transport



For sediment resuspension the lift force due to the flow around it must exceed the gravity force.

The lift and drag forces slow the water and this effective force per unit area is called the shear stress.

Bedforms have a similar effect on the flow... they slow it down.



Shields Curve



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Stress

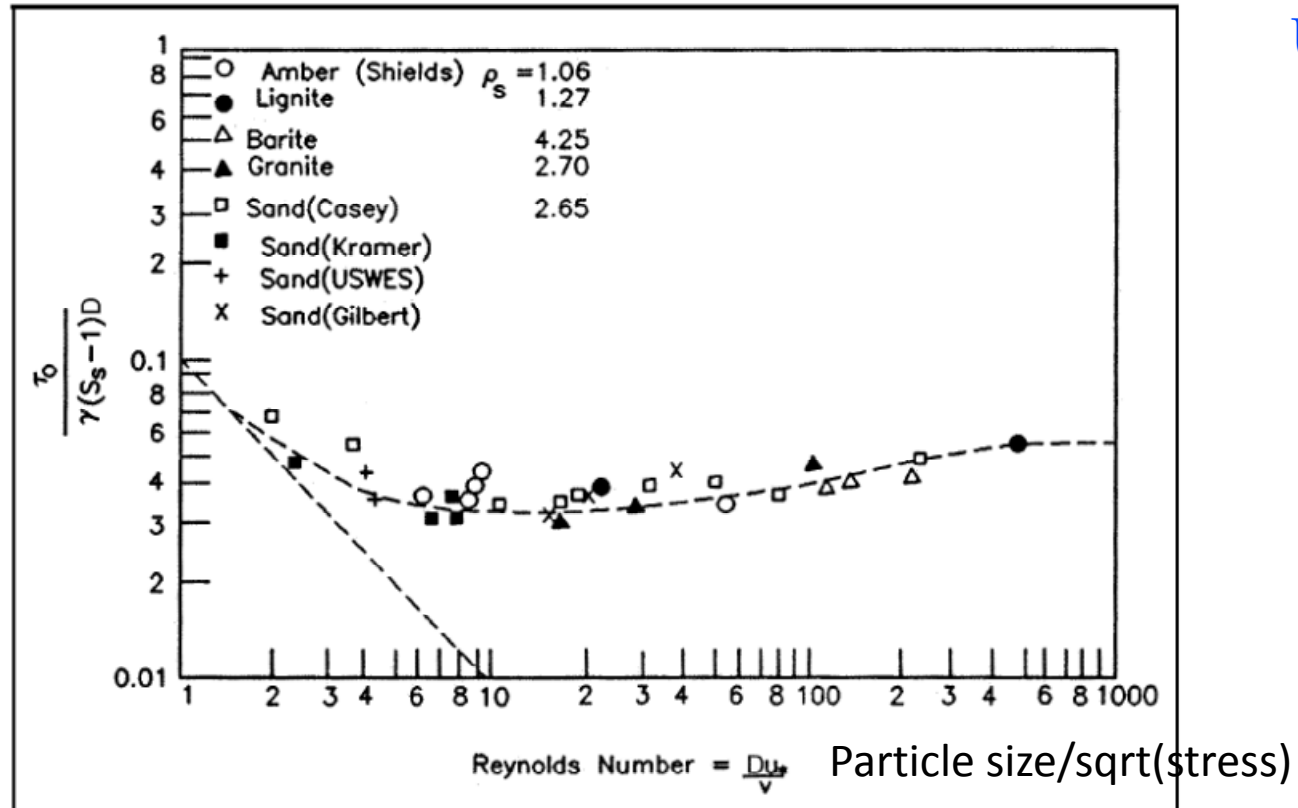


Figure III-6-7. Shields diagram for initiation of motion in steady turbulent flow (from Raudkivi (1967))

More simply



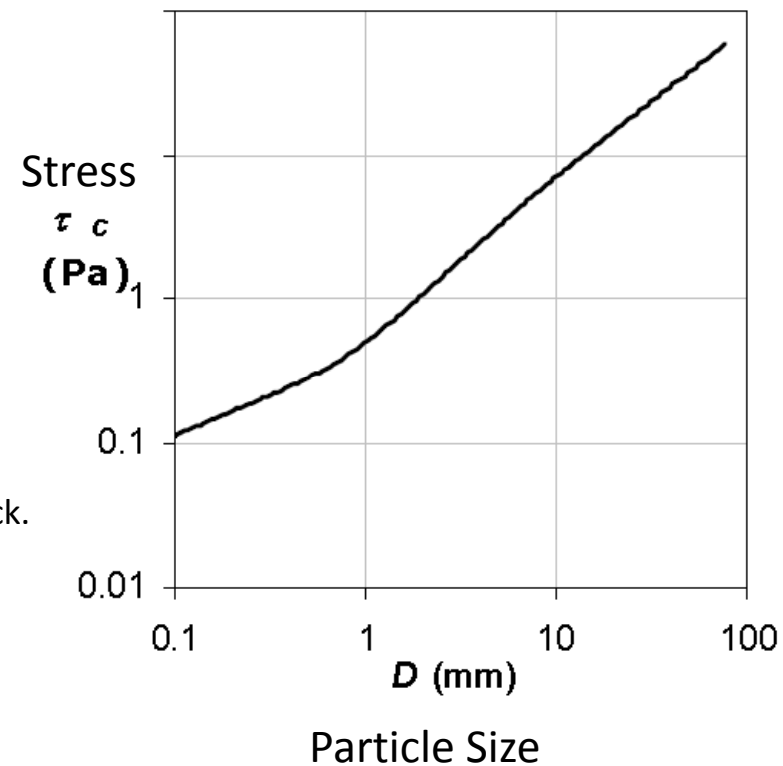
$$S^* = \frac{\sqrt{(s-1)gD^3}}{\mu/\rho} \text{ and } s = \frac{\rho_s}{\rho} \quad (2.65 \pm 5\%)$$

The trend on the diagram can be represented by the function

$$\tau_c^* = 0.105(S^*)^{-0.3} + 0.045 \exp[-35(S^*)^{-0.59}]$$

From: Peter Wilcock, UC Berkeley

<http://calm.geo.berkeley.edu/geomorph//wilcock/wilcock.html>



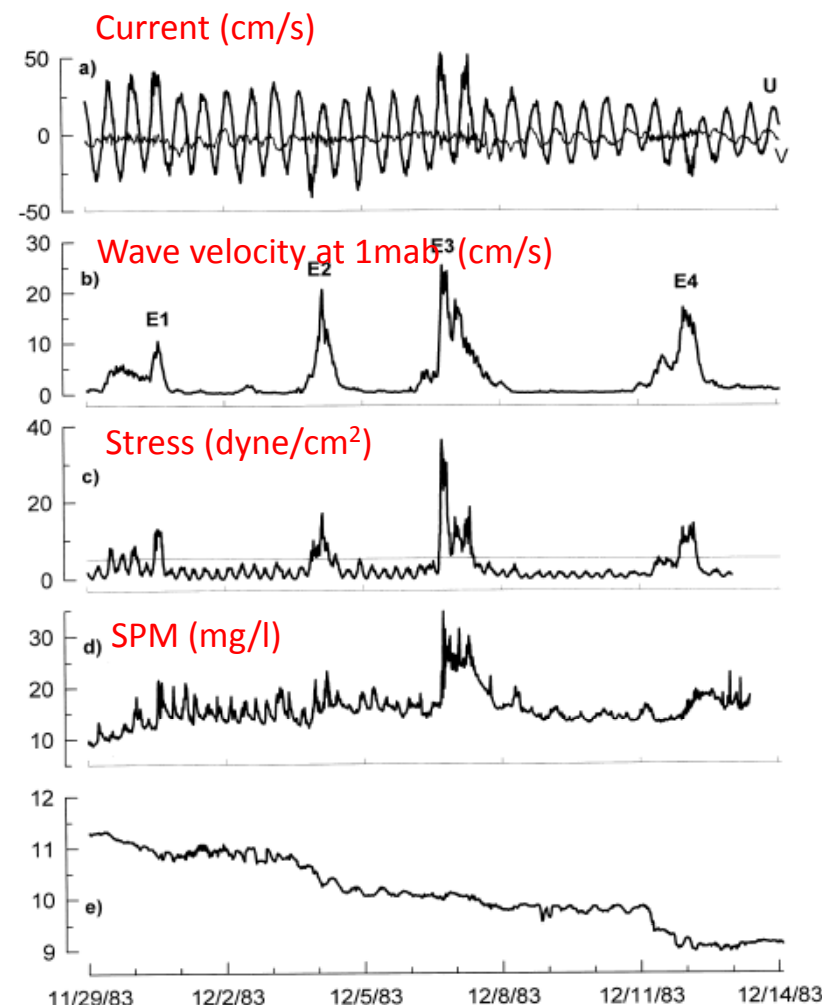
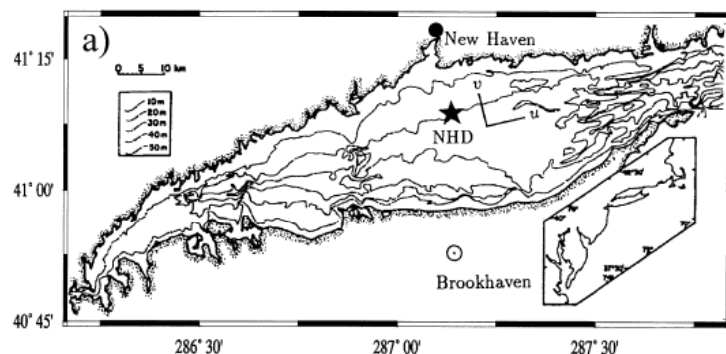
Storm Enhanced Bottom Shear Stress and Associated Sediment Entrainment in a Moderate Energetic Estuary

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Several important mechanisms for storm-induced entrainment of estuarine cohesive sediments are analyzed using field measurements collected in a moderately energetic estuary, central Long Island Sound, U.S.A. The sediment concentration hydrographic data were obtained by an array of sensors mounted at 1 m above bottom. The bottom sediment in the study site composed mostly of silt and silty s. The study showed that the bottom shear stress, computed using a wave-current interaction model, increased significantly during the episodic wind events. A large resuspension event was triggered by a frontal passage when strong wind-driven currents augmented the tidal currents. The timing of storm waves with respect to tidal phase also was a critical factor. Based on the changes of suspended sediment concentration, the bottom appeared to respond to the shear stress in two phases: tidal resuspension and the storm-induced erosion. During each tidal cycle, entrainment was associated with resuspension of high water content, loosely consolidated material. During episodic events, a thin layer of more consolidated bed below sediment-water interface was eroded by the enhanced bottom stress.



2. Summary of data needs – controlling factors.



1. Current in the ZSF controlled by tides, density variations and winds.
2. Bottom stress is determined by current and waves.
3. Waves are generated by wind.
4. We want to know the circulation and stress during normal conditions (for each season) and for extreme conditions.
5. We can only observe them all for selected interval and at a few places so we need a model to generalize the observations.



3. What is available ?

- Three great resources:

1. Woods Hole Group (201). Long Island Sound Dredged Material Management Plan (DMMP) Phase 2 Literature Review Update June 2010, Prepared for U.S. Army Corp of Engineers, Contract No. W912WJ-09-D-0001-TO-0022
2. O'Donnell, J., R. E. Wilson, K. Lwiza, M. Whitney, W. F. Bohlen, D. Codiga, T. Fake, D. Fribance, M. Bowman, and J. Varekamp (2013). The Physical Oceanography of Long Island Sound. In *Long Island Sound: Prospects for the Urban Sea*. Latimer, J.S., Tedesco, M., Swanson, R.L., Yarish, C., Stacey, P., Garza, C. (Eds.), 2013 (Elsevier, In press).
3. Codiga, D. L. and David S. Ullman (2010). Characterizing the Physical Oceanography of Coastal Waters Off Rhode Island, Part 1: Literature Review, Available Observations, and A Representative Model Simulation
(<http://seagrant.gso.uri.edu/oceansamp/pdf/appendix/02-PhysOcPart1-OSAMP-CodigaUllman2010.pdf>.)

- And our Task 2 report

4. Summary of data needs – variables



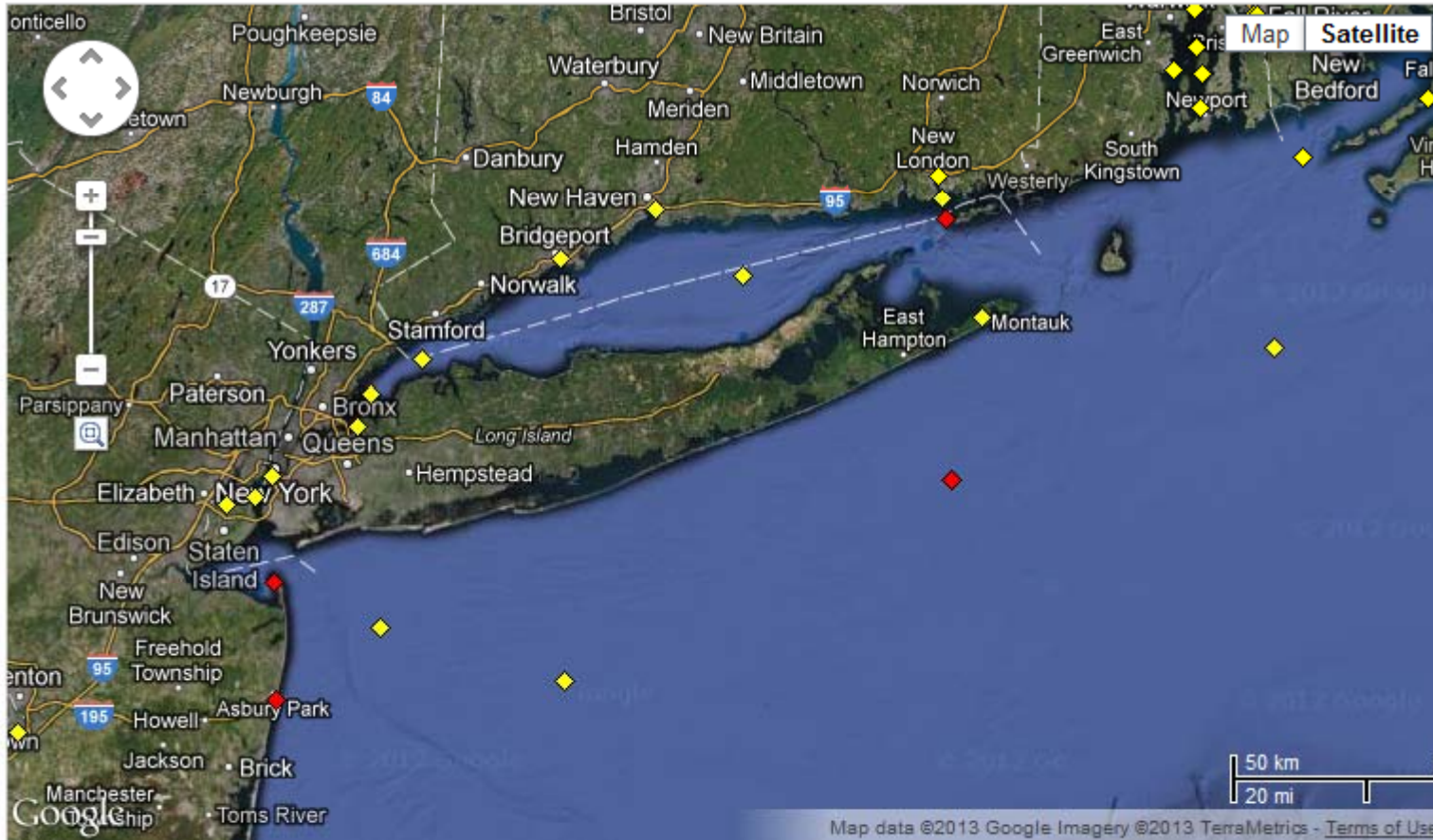
1. Sea level at the edge of the shelf to force tides and the interior of the model domain to check it.
2. Wind over the ocean to force the circulation and waves.
3. Solar radiation to force temperature variations.
4. River discharge measurements to force variations in salinity.
5. Salinity and temperature measurements at boundaries to prescribe conditions and in the interior to check predictions.
6. Current measurements to evaluate the model predictions
7. Wave measurements to evaluate the model predictions
8. Bottom stress measurements to evaluate the model prediction

Sea Level



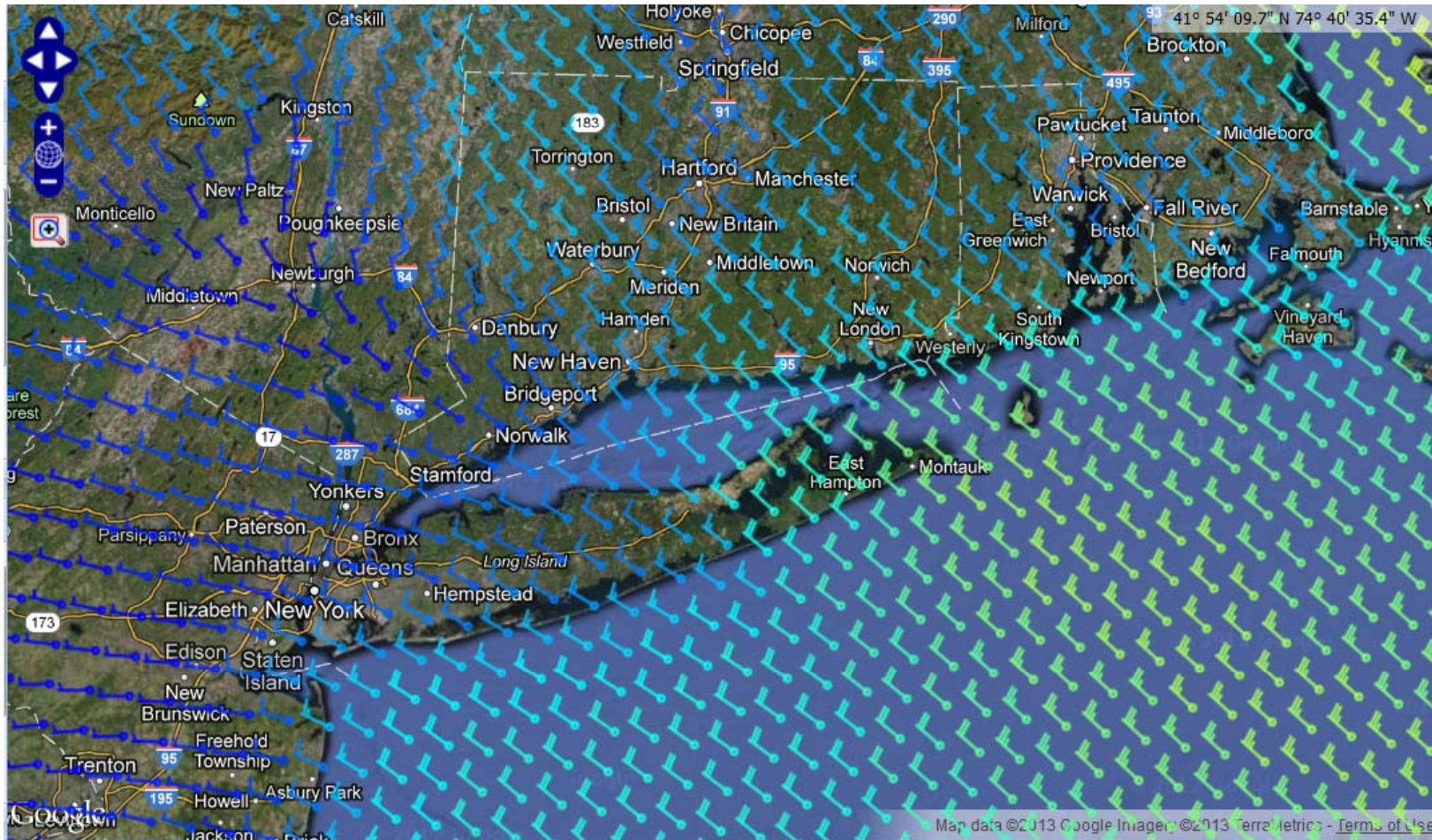
<http://tidesandcurrents.noaa.gov/geo.shtml?location=Bridgeport>

Wind-data



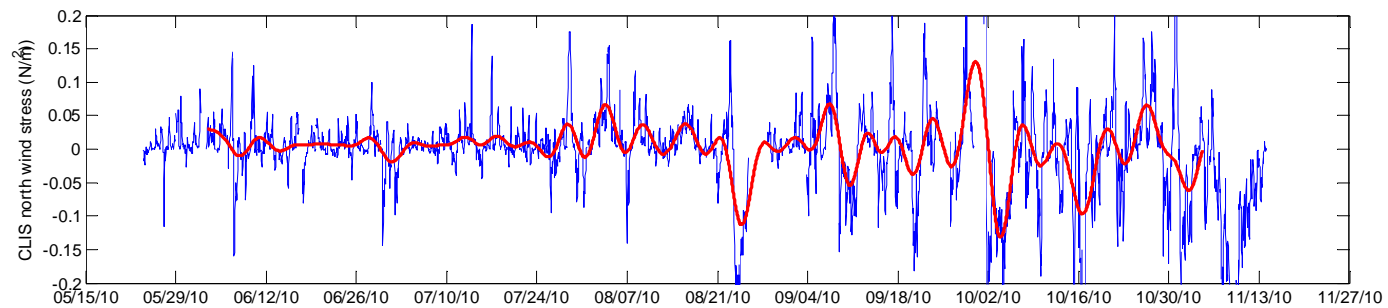
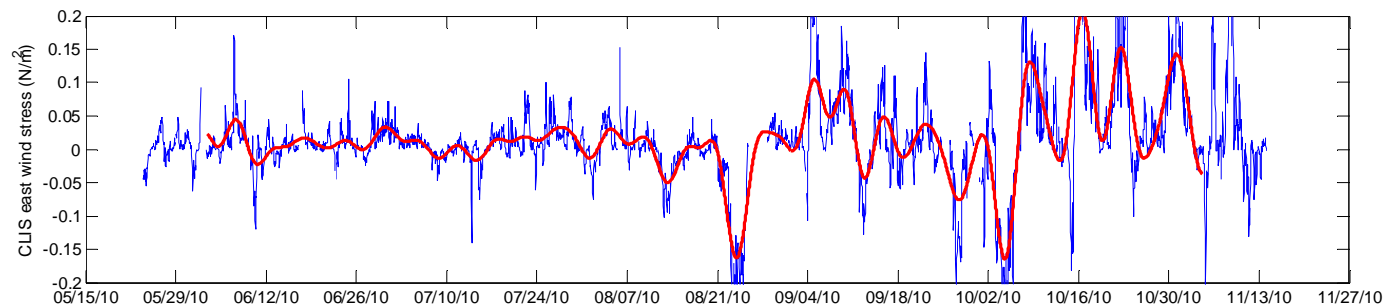
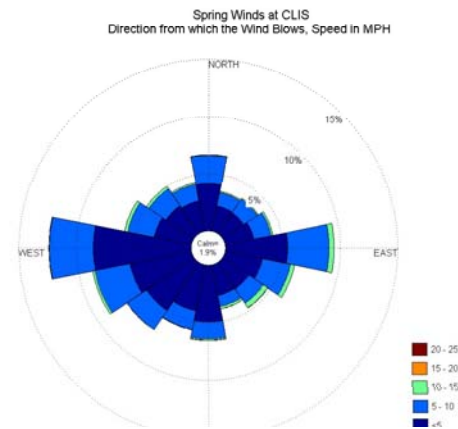
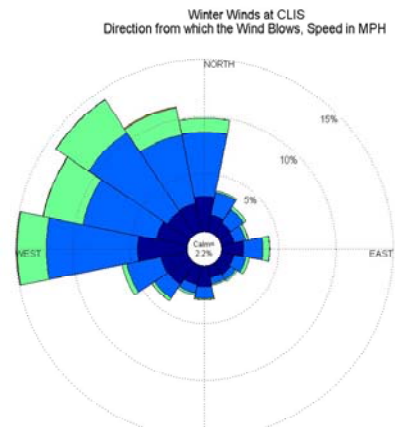
<http://www.ndbc.noaa.gov/>

Wind- Analyses



Forecast from <http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/>
Viewer: <http://maracoos.org>

Seasonal variation in Wind



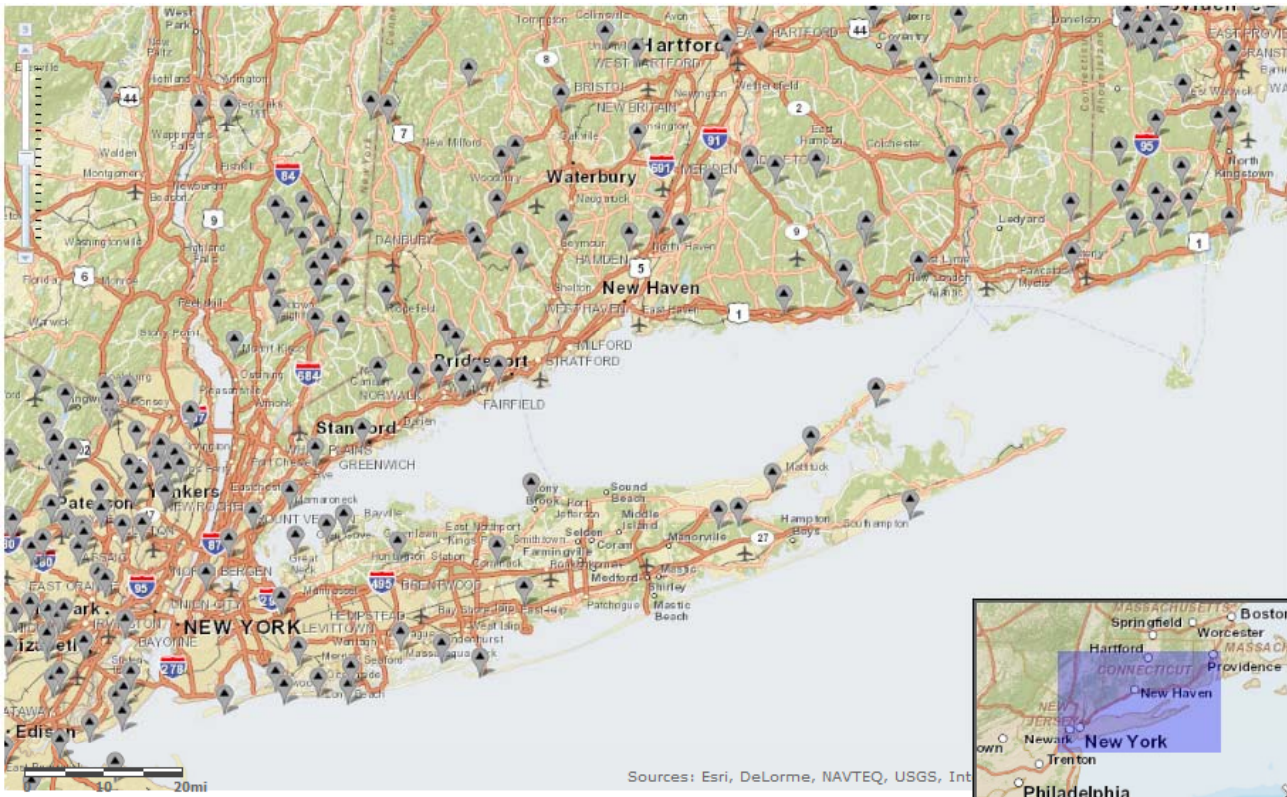
Radiation



DATA



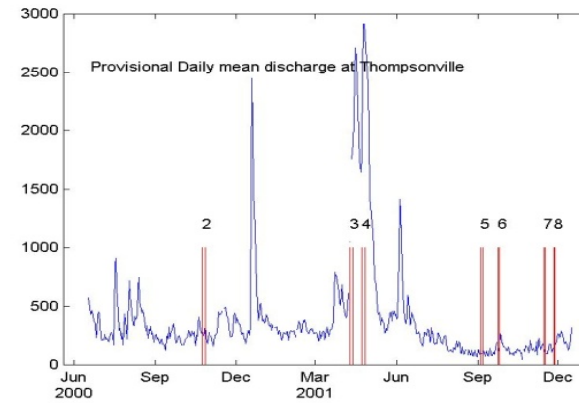
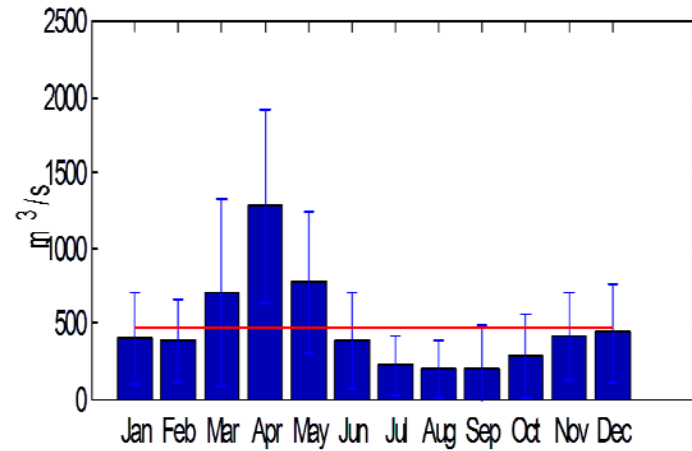
River Discharge (water level)



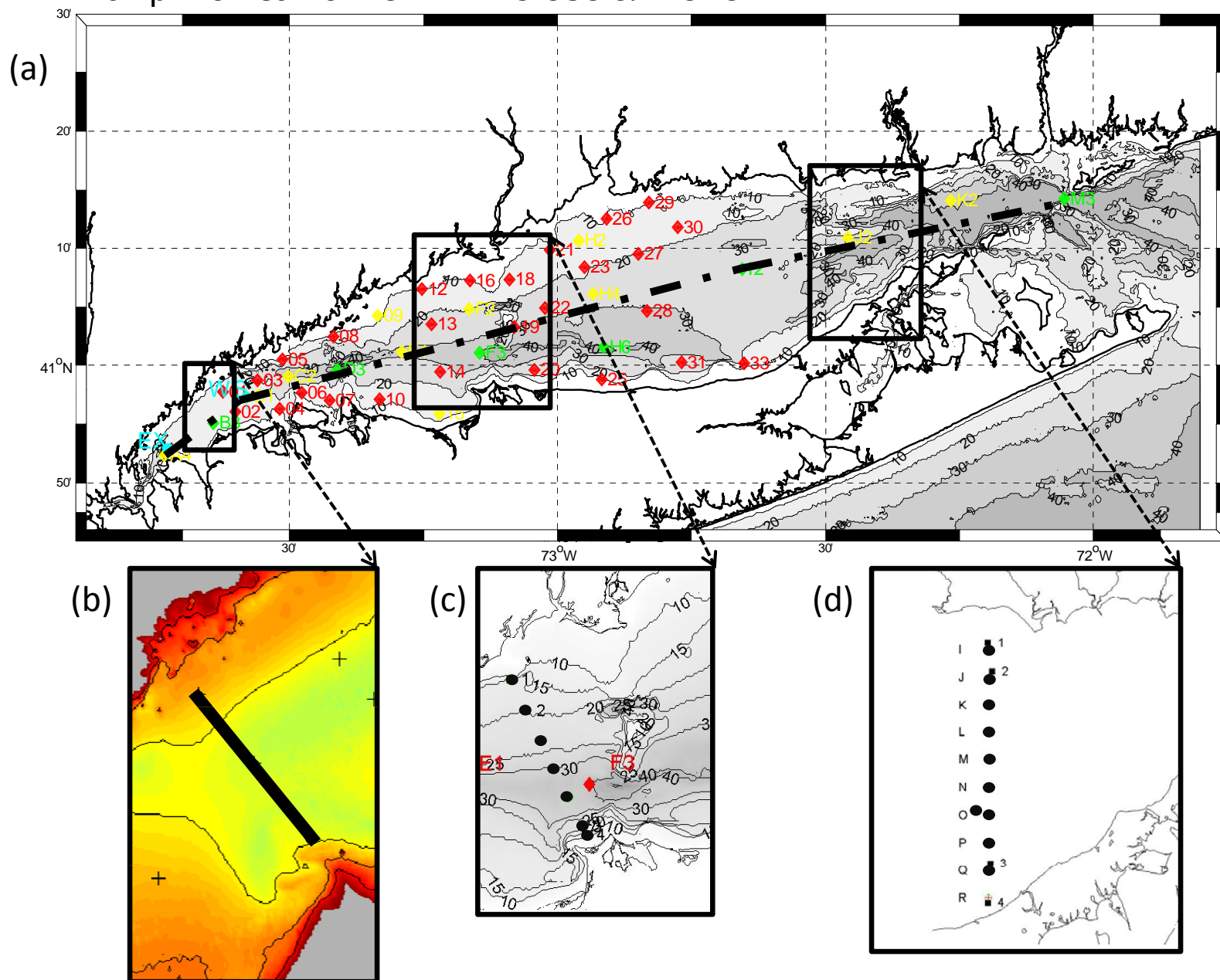
<http://maps.waterdata.usgs.gov/mapper/index.html?state=ct>

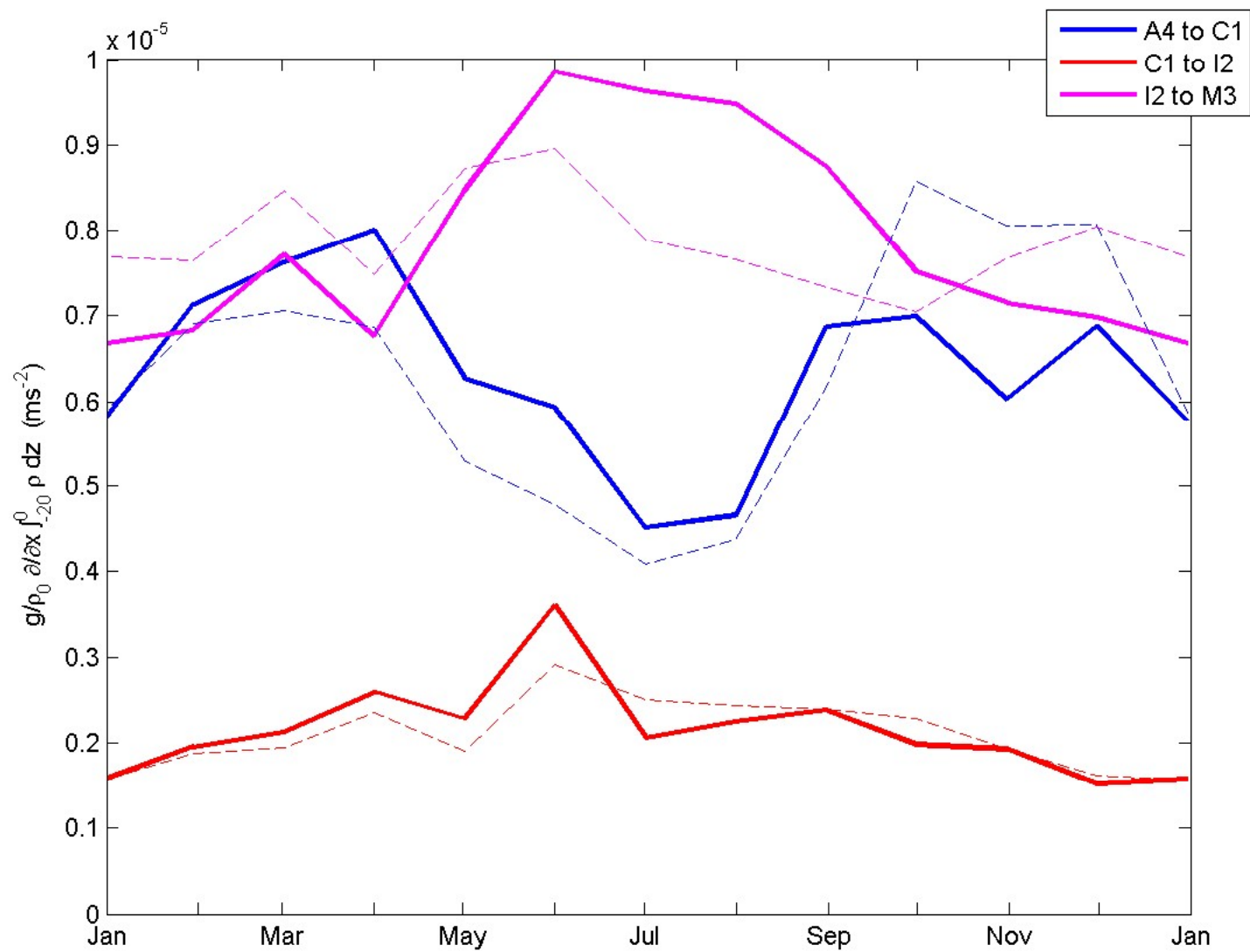
USGS maintains a large network of level/flow gauges. Most freshwater arrives through a few (~10) source and we will focus effort on these.

Seasonal Variability in River Discharge



Salinity & temperature -ship Profiles from CTDEP. LISICOS & RESLIS

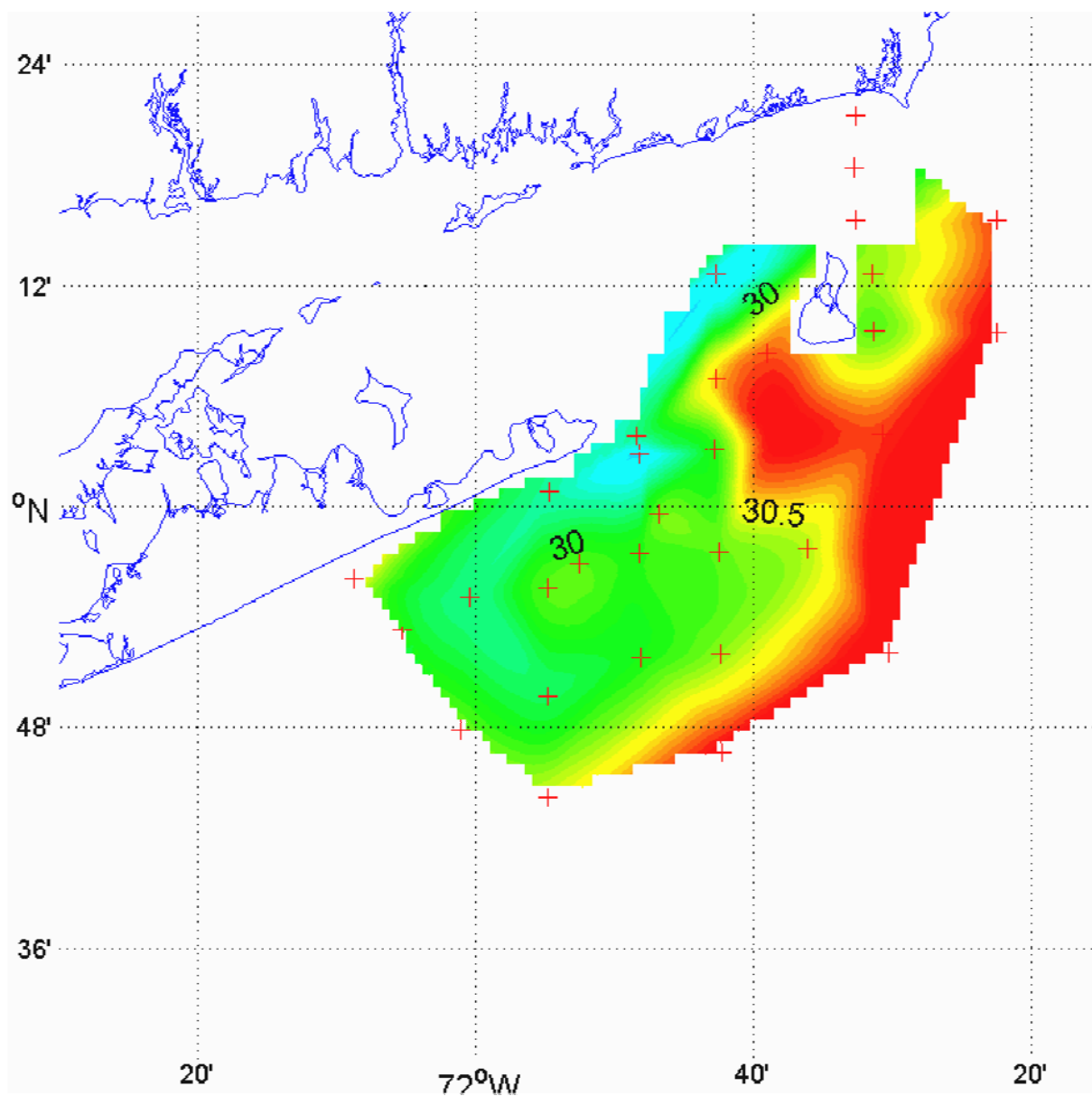




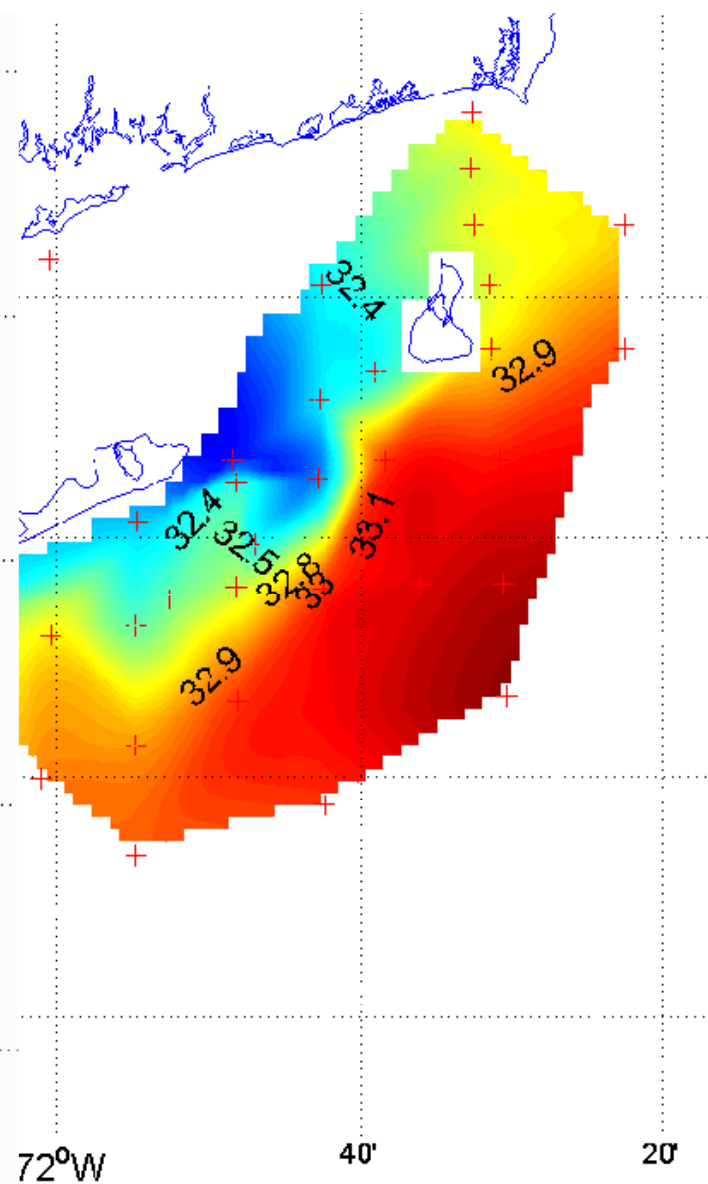
Salinity & temperature Ship Profiles – FRONT program

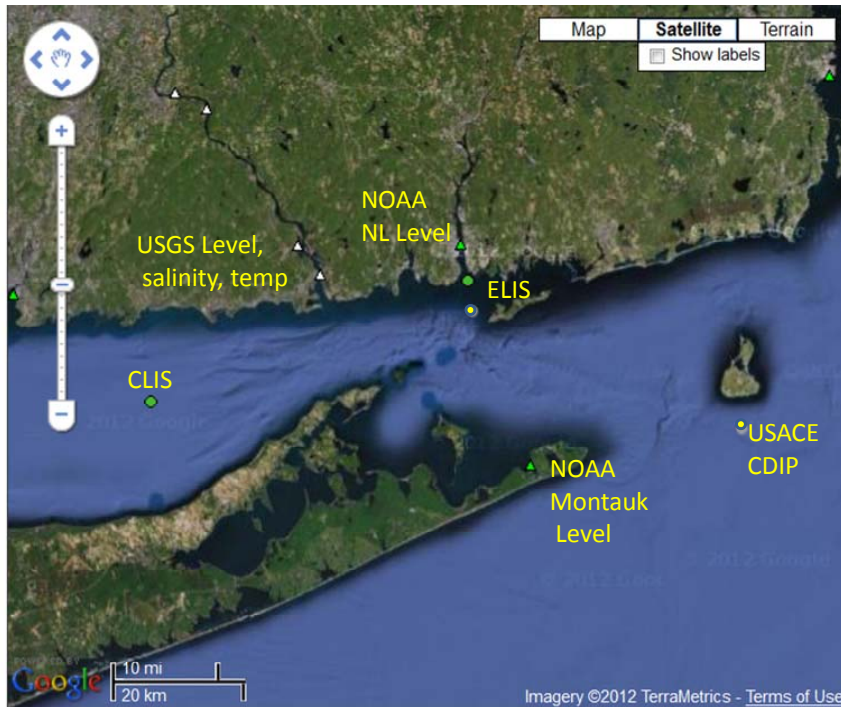


JNS4: April 23-25, 2001



JNS8: Nov 26-27 2001





Salinity & temperature, from Buoys.

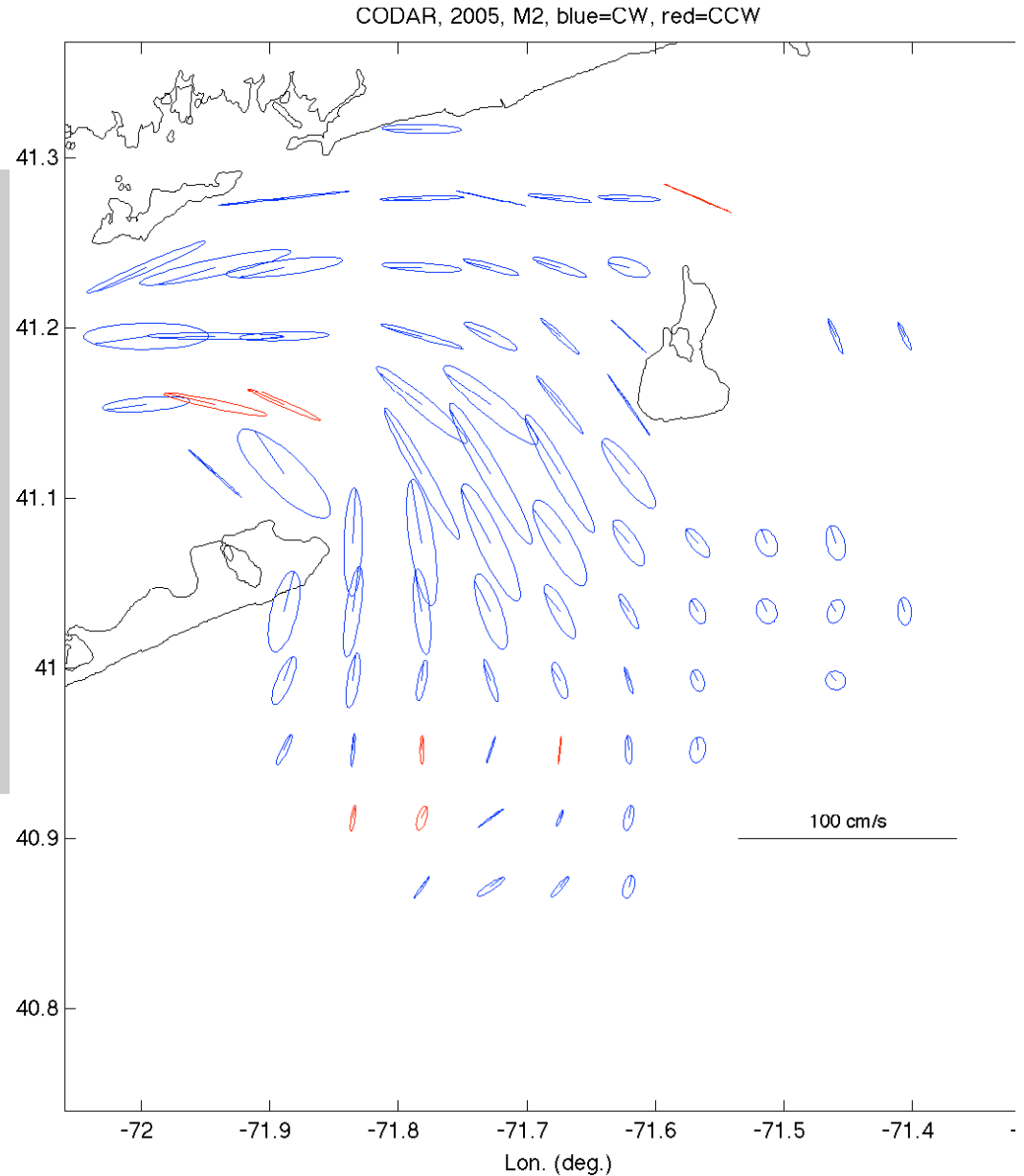
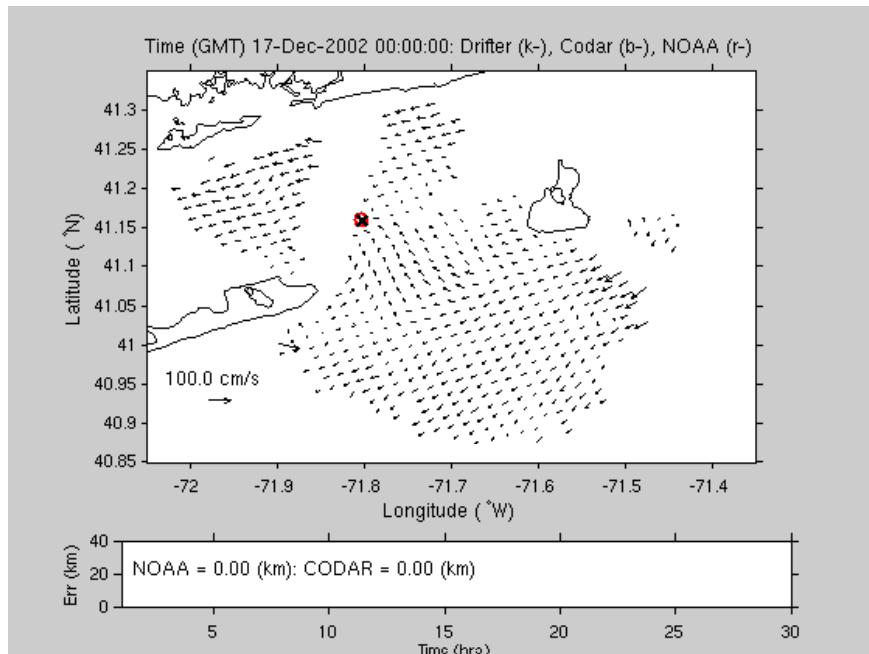


S-salinity, T-temperature, DO-dissolved oxygen (membrane sensor),
O-dissolved oxygen (optical sensor), CH-chlorophyll (RFU only)

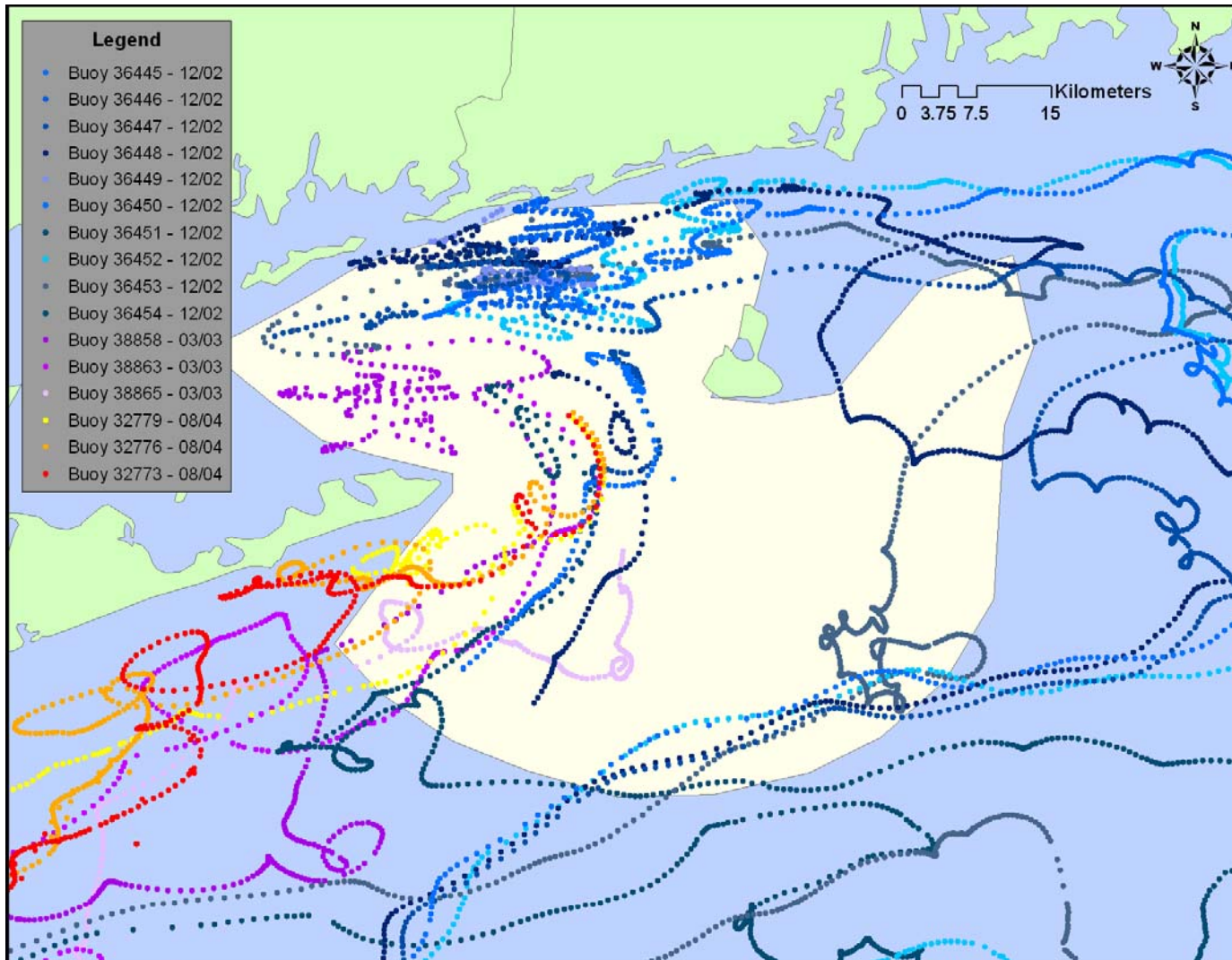
	<u>CLIS Water</u>			ELIS water		
Year	SFC	MID	BTM	SFC	MID	BTM
2012	S,T,CH,O	---	---	---	---	---
2011	S,T,CH,O	---	---	---	---	---
2010	S,T,CH,O	---	---	S,T,DO	---	---
2009	S,T,CH,O	---	---	S,T,DO	---	---
2008	S,T,DO	---	---	S,T,DO	---	---
2007	S,T,DO	---	---	S,T,DO	---	---
2006	S,T,DO	---	---	S,T,DO	---	---
2005	S,T,DO	S,T,DO	S,T,DO	S,T,DO	---	S,T,DO
2004	S,T,DO	S,T,DO	S,T,DO	S,T,DO	---	S,T,DO
2003	S,T,DO	S,T,DO	S,T,DO	S,T,DO	---	S,T,DO
2002	S,T,DO	S,T,DO	S,T,DO	S,T,DO	---	S,T,DO
2001	---	---	---	S,T,DO	---	S,T,DO
2000	---	---	---	S,T,DO	---	S,T,DO
1999	---	---	---	S,T,DO	---	---

Currents: HF RADAR Vectors in BIS

2002 - 2012



Currents: Lagrangian Drifter Data from BIS



GPS Drifter Tracks

Dec 2002

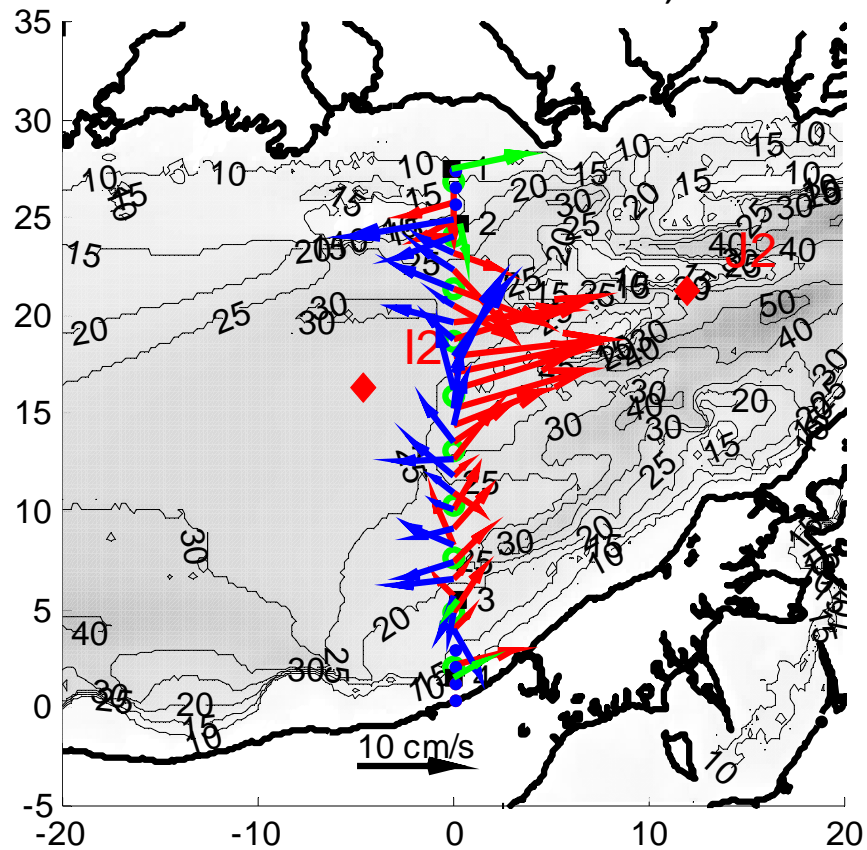
March 2003

August 2004

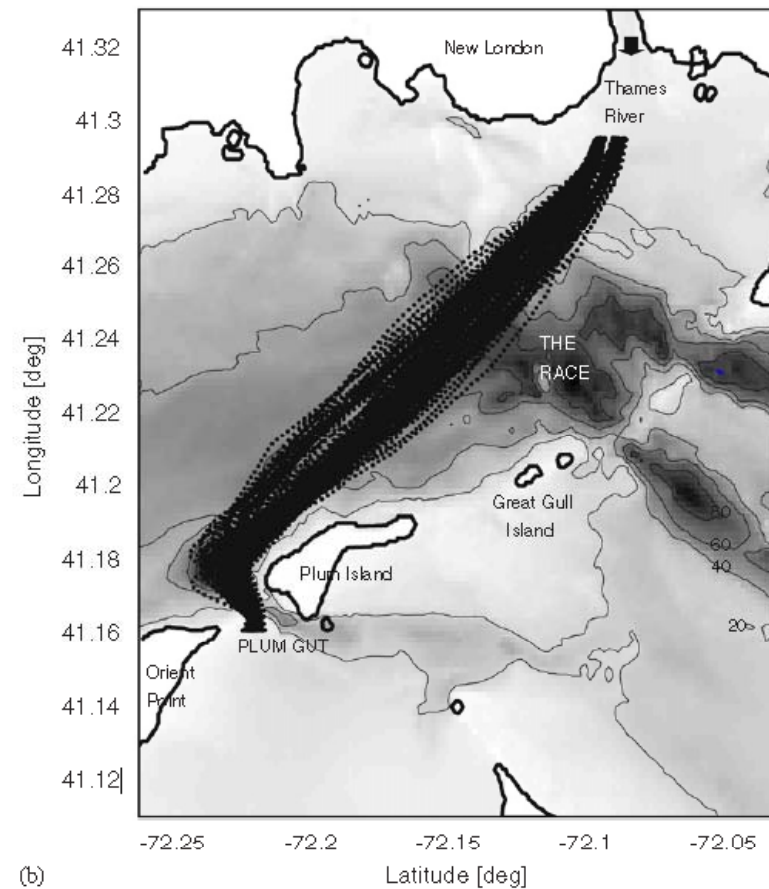
White region
represents where
CODAR
observations are
obtained more than
10% of the time

Currents from Ship Surveys: RESLIS and NL-OP Ferrry

From 'Donnell & Bohlen, 2003

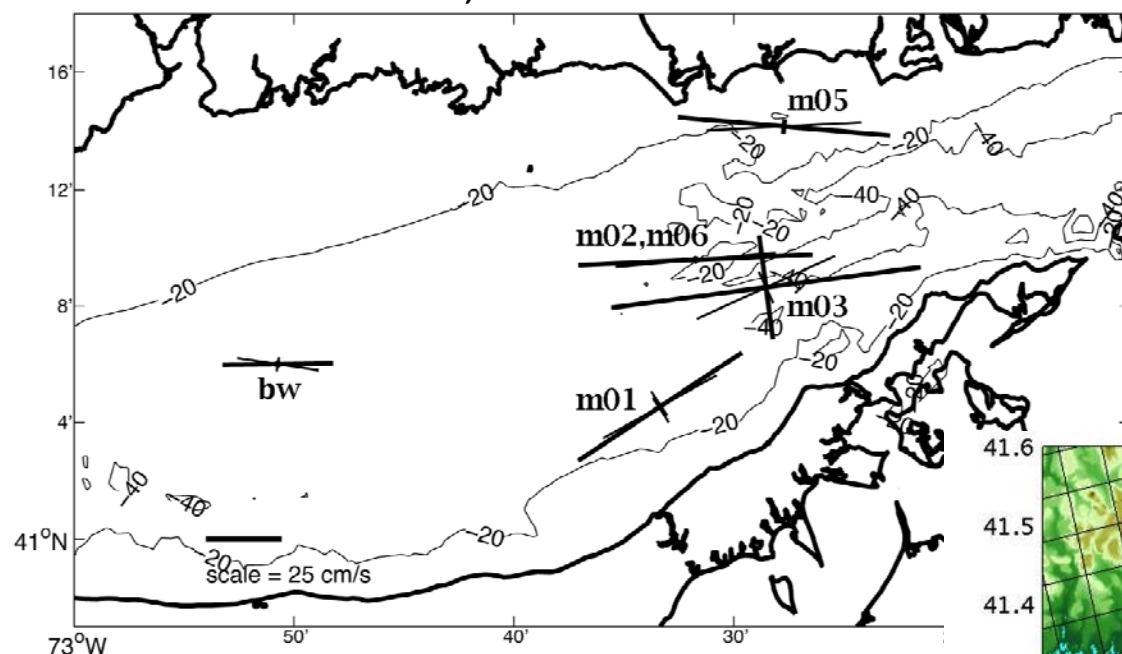


From Codiga & Aurin, (2007)

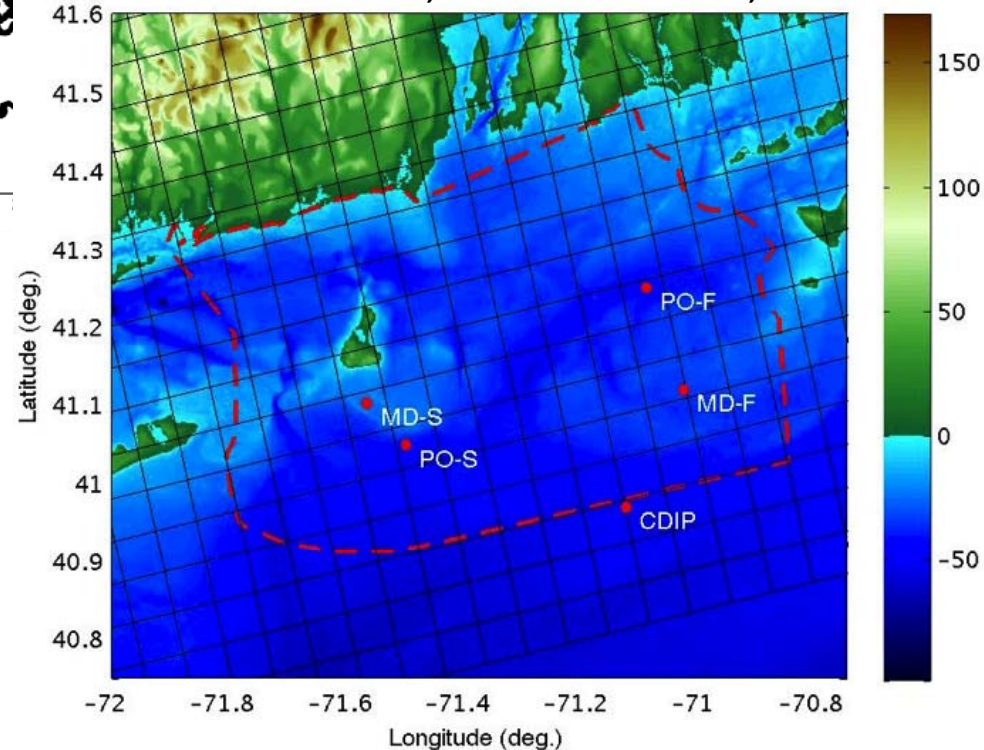


Currents from Moorings

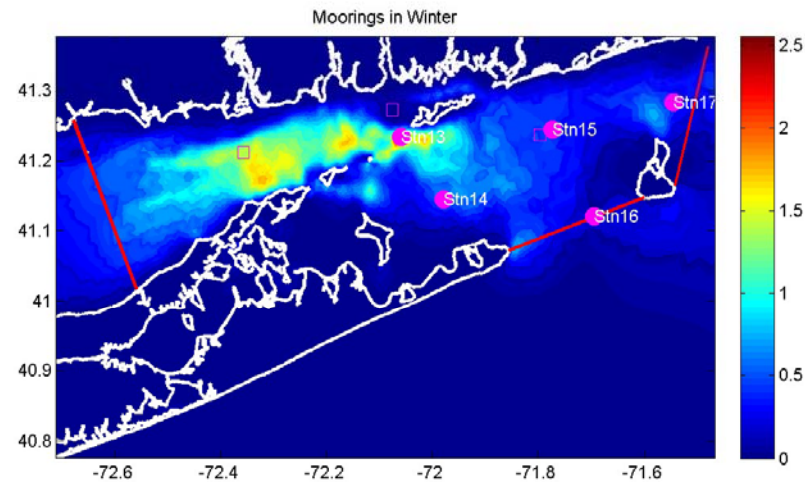
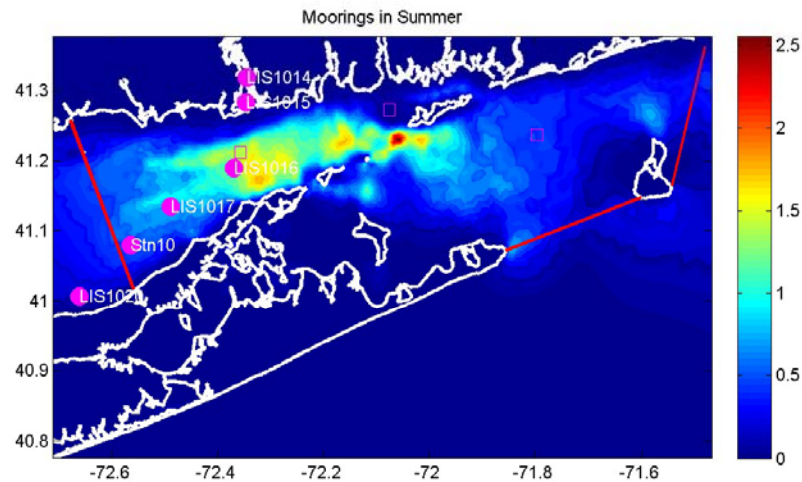
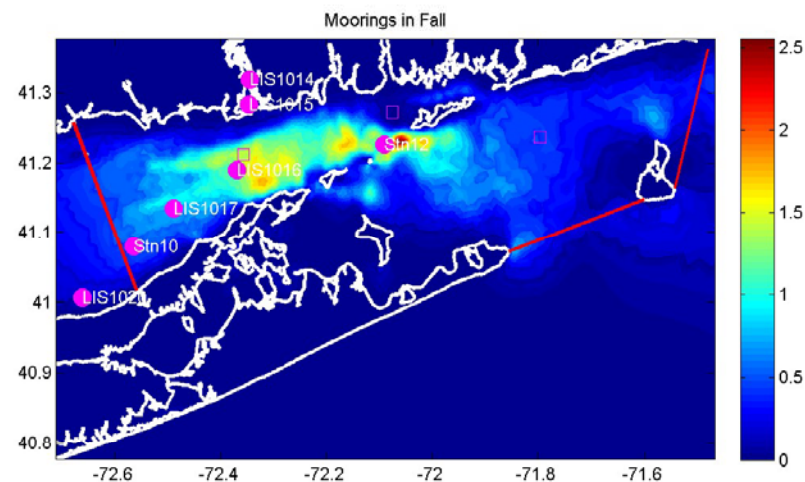
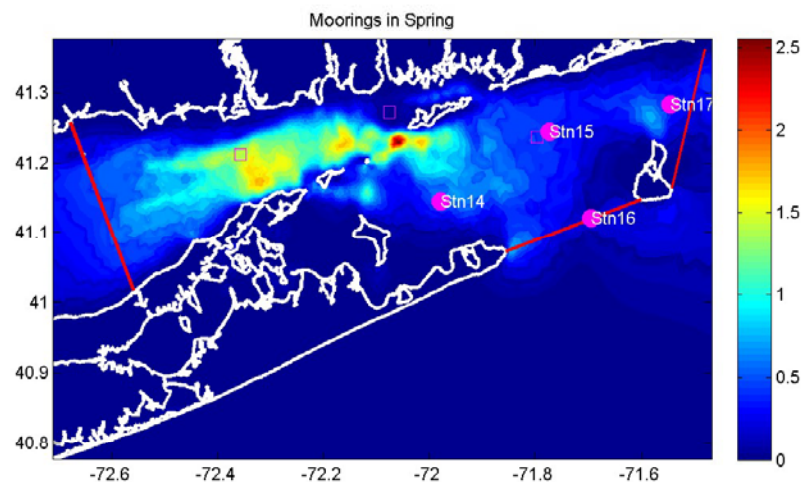
LISICOS, From Bennett et al. 2010



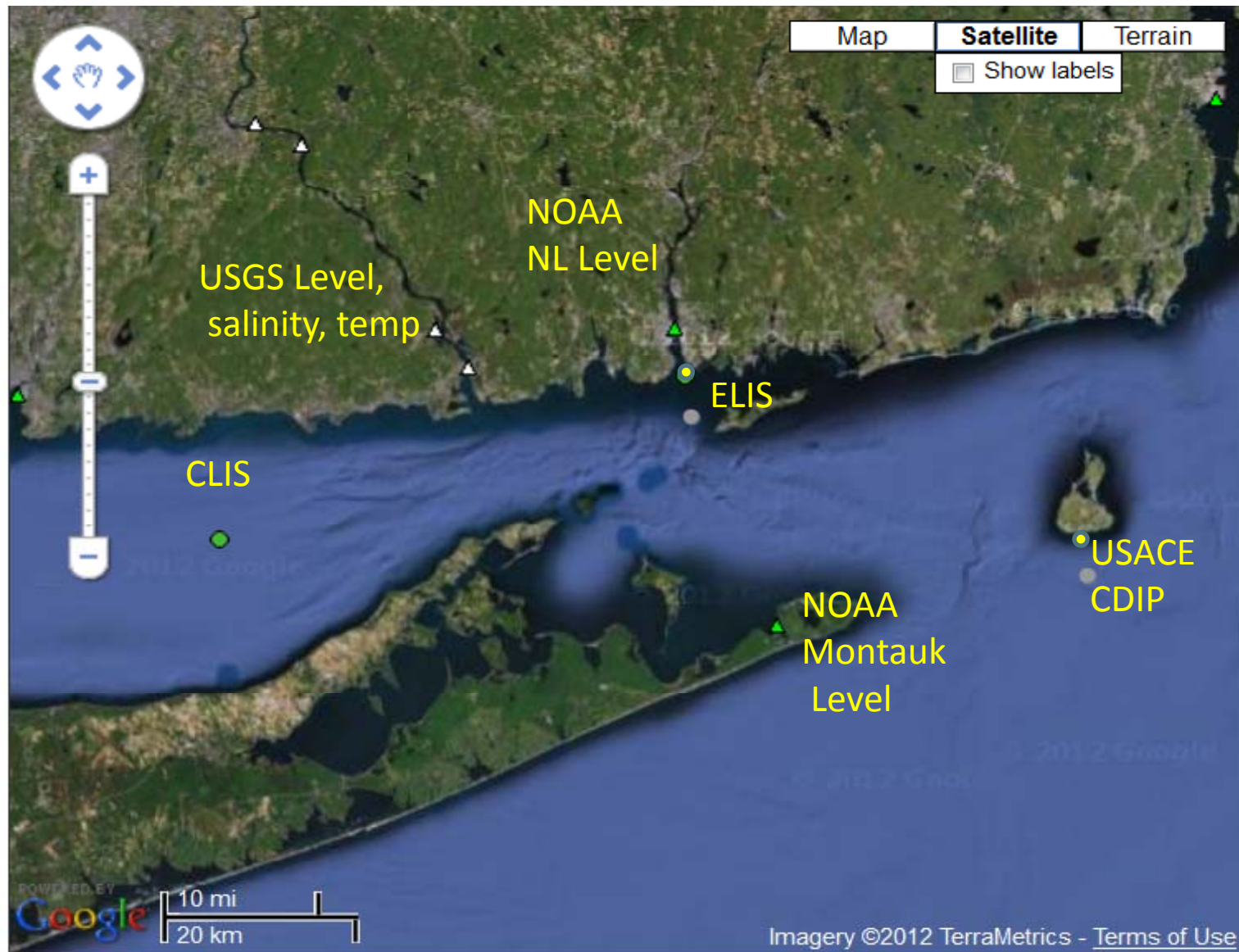
RI SAMP, From Grilli et al, 2011



NOAA Current Meters 1988-89 & 2010



Waves



Bottom Stress – no measurements



Summary



- No Stress
- Waves only at CLIS buoy ZSF
- No North-Sound variation in density in LIS
- No hydrography or current profile measurements in BS-RIS
- Seasonal variations in wind & wave and river discharge are substantial.

5. Proposal for Observations

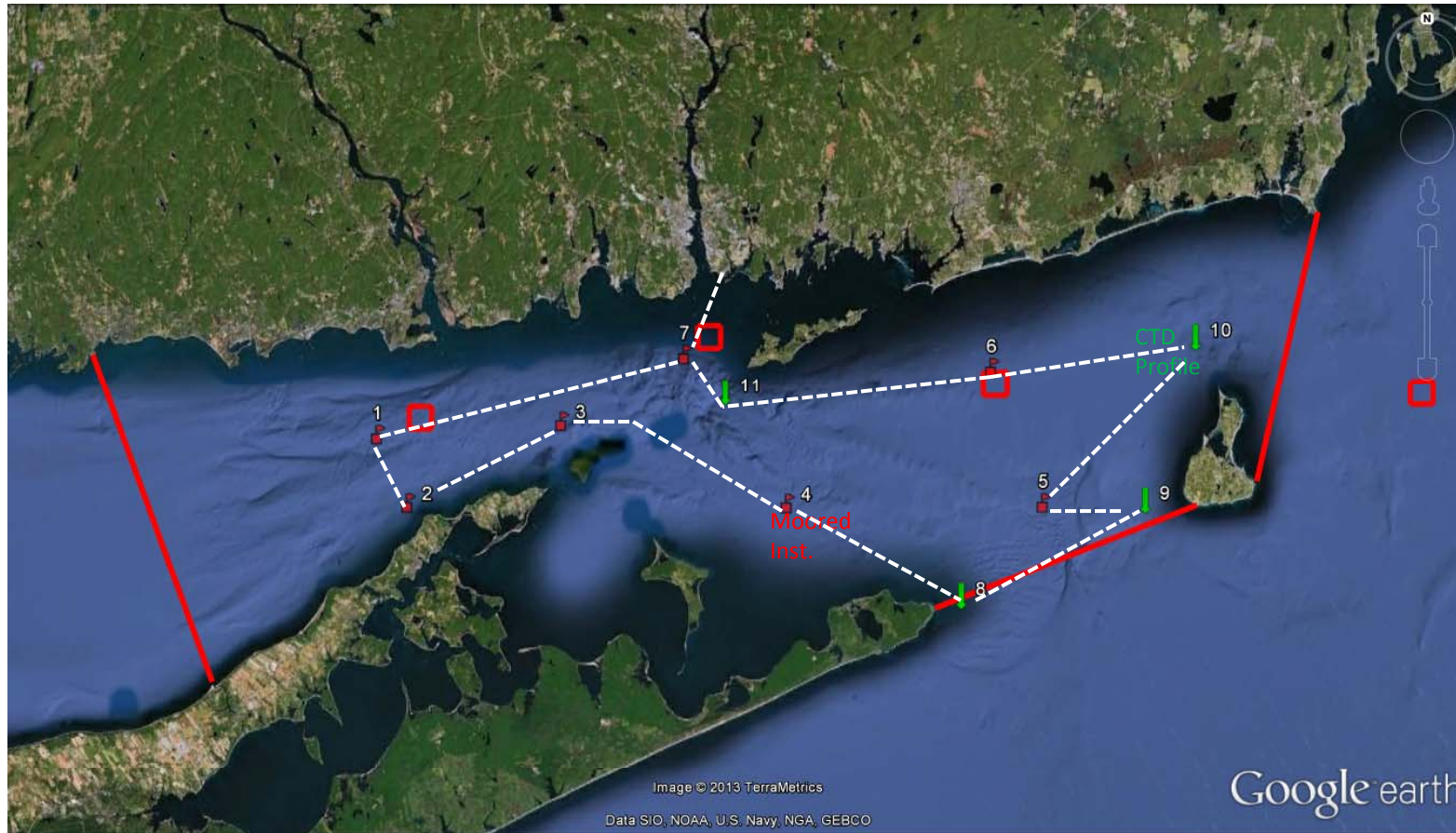


- October-March have frequent high winds from NE
- Wind forcing is less in May-Sept
- River Flow is high Mar-May and below average the rest of the year
- Need current, wave and stress measurement in a range of locations in each forcing regime.
 - Windy, low flow (Feb-March)
 - Windy High Flow (April-May)
 - Calm, below average flow (June-July)

Stations, ZSF and Disposal Sites



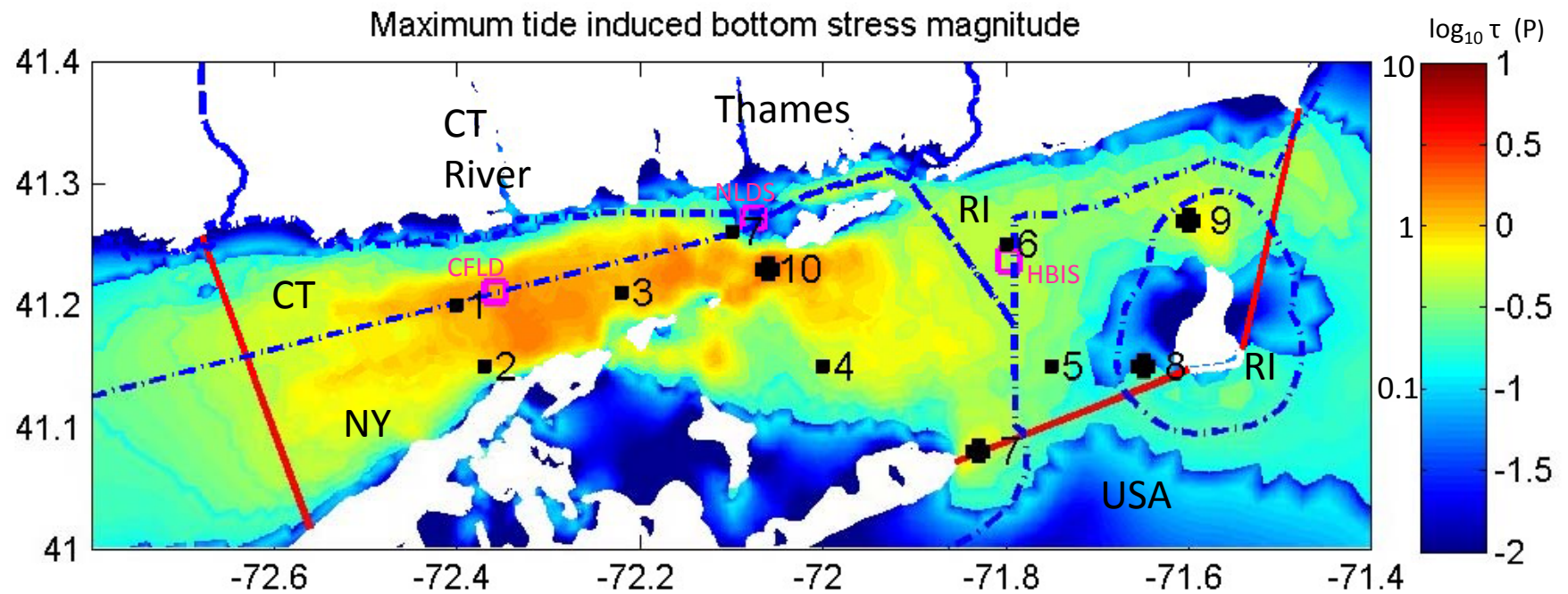
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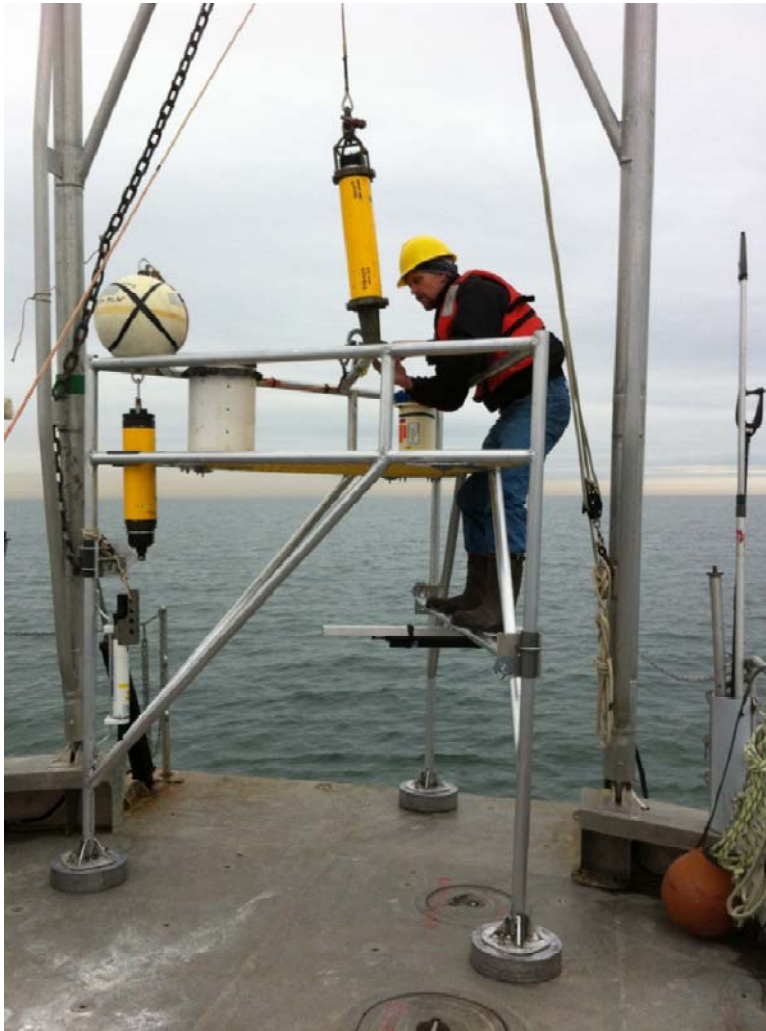


Stations, ZSF and Disposal Sites on preliminary stress estimate



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Bottom Instrumentation

1. Upward looking RDI ADCP to measure profile (1-0.5m resolution) of current and wave statistics
2. Downward looking Nortek ADCP with 5cm resolution bottom to 75cm to measure stress and acoustic backscatter intensity
3. CTD to measure salinity, temperature and bottom pressure
4. Optical backscatter at .2 and .8 m to infer SPM concentrations



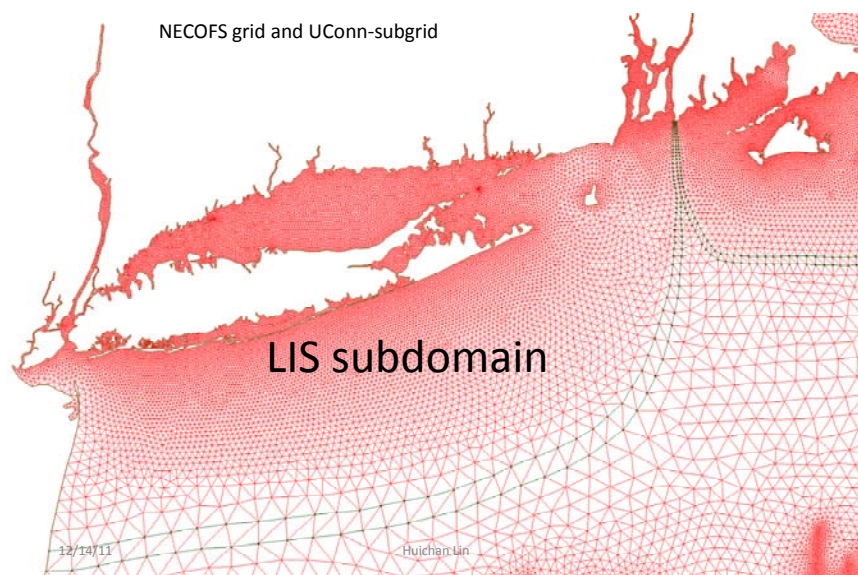
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Profiling Instrumentation

1. Hull mounted ADCP to survey current patterns
2. CTD to measure salinity, temperature and pressure
3. OBS 3+, optical backscatter to infer SPM concentrations
4. Water sampler for SPM concentration calibrations
5. LISST-100 to measure particle size spectra
6. AC9 Optical absorption spectra for discriminating organic and inorganic material

Model - FVCOM



Outer domain simulated by UMass
Operationally through NOAA funding

This is a well established code and has been implemented in LIS already.

It is nested inside the UMass Dartmouth Regional Model.

FVCOM will be used to simulate the circulation and wave height and period distributions.

Challenges are to get hydrography variability correct in the ZSF domain and wave model implemented and assessed.

Integration of Model and Data



- Use observed winds and river flows to drive model and predict the salinity, temperature, current and waves, and bottom stress.
- Compare to the new and archived observations and evaluate FVCOM performance in LIS.
- Describe the uncertainties.
- Simulate the behavior under extreme events

Analyses

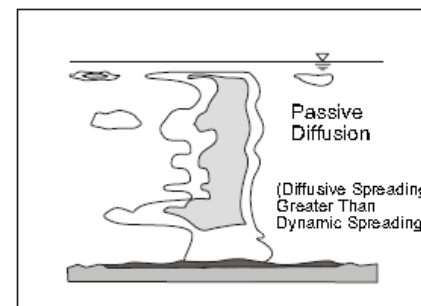
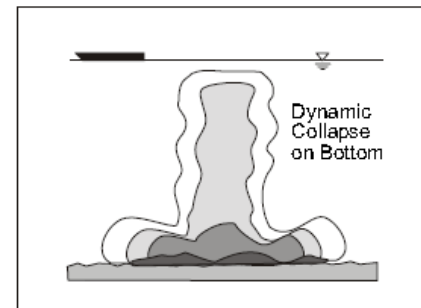
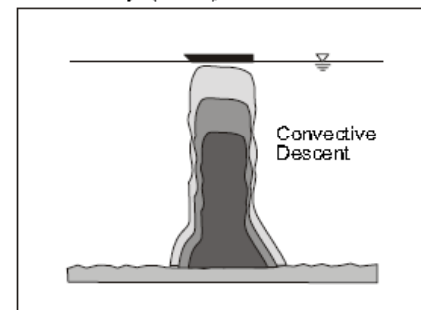


- Observations and model predictions will be used to describe the distributions of current and stress for site screening.
- When sites are being considered their results will be used to drive the STFATE and LTFATE models.

Models STFATE- LTFATE



- STFATE – Near field transport during disposal operations
- FVCOM will provide currents, waves and shear for STFATE studies at sites under consideration



LTFATE



- LTFATE simulates the long term transport of resuspended materials from disposal mound. This requires regional current patterns, and waves forecasts from FVCOM. We will simulate the effects of historic events at alternative sites



- Questions and advice?